IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF TEXAS
HOUSTON DIVISION

FISHER-ROSEMOUNT SYSTEMS, INC. and EMERSON PROCESS MANAGEMENT LLLP,	Case No. 4:18-cv-00178-KPE
Plaintiffs,	
v.	
ABB LTD, ABB, INC., ABB AB, and ABB AUTOMATION GMBH,	
Defendant.	

PLAINTIFFS' TECHNOLOGY TUTORIAL

I.   INTRODUCTION

The inventions claimed by U.S. Patent Nos. 8,332,567 (the '567 Patent), 9,411,769 (the

'769 Patent), and 7,684,875 (the '875 Patent) relate to process control. A typical application of

process control technology is to control oil refining processes. The '567 and '769 Patents relate

to *apparatuses* for managing communication connections between a controller or controllers and

field devices used in all process control systems. The '875 Patent relates to *systems and methods*

for automatically configuring those connections between the controller(s) and the field devices.

Controllers and field devices are essential to controlling a process. Field devices send

information about process activities to controllers which, in turn, send information to other field

devices for making adjustments to process activities. In a typical oil refinery there can be

thousands of field devices spread across miles of territory and all must be in communication with

controllers and a central work station where an operator monitors the process control system.

The inventions here revolutionized the creation and improvement of process control systems by

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making it easier for engineers to connect field devices to controller(s), simplified configuring

these connections, cut costs in design and labor, and reduced wiring. In this technology tutorial,

Plaintiffs Fisher-Rosemount Systems, Inc. and Emerson Process Management LLLP

(collectively, "Emerson") will explain these concepts and demonstrate the described

improvements.

II.   PROCESS CONTROL 101

To begin, process control systems oversee devices performing a process that creates or

changes something by performing the process. As an example, refining oil is a process, and

process control systems oversee the machinery and devices transforming crude oil into, for

example, gasoline. It also controls the processing of oil byproducts, waste water treatment, and

fire control systems. That said, process control spans numerous industries far beyond just oil

refineries, including manufacturing, pharmaceuticals, chemicals, and more.

As mentioned above, process control oversees electronic devices comprising a factory,

plant, refinery, or any other facility performing a process. To simplify, the electronic devices that

comprise a process control system generally include three groups: controllers, input/output

devices, and field devices.

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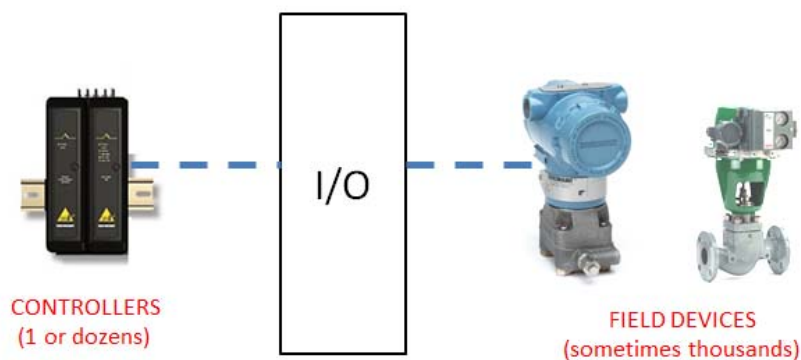
Depending on the facility performing process control, a process control system can include one controller or dozens of controllers. Conversely, a facility's process control system can include numerous, sometimes thousands, of field devices. The controller(s) communicate with the field devices through an input/output (I/O) system, and the I/O system manages the connections to the field devices. Emerson will describe the specifics of each of the three process control groups below.

Below is a graphic illustration of a process controls system: controller(s) connect to the field devices through the I/O system and communicate with the field devices through respective connections. Importantly, some field devices *transmit data to the controller(s)* (e.g.

temperature data), and some field devices *perform actions* which impact the process (e.g. close a valve) being controlled in response to *commands from the controller(s)*. For example, a temperature sensor field device can read a temperature of a fluid flowing through the pipe shown above, the temperature sensor can transmit the detected temperature to the controller, and the controller can make a decision based on the temperature received. Further, the controller can determine that the temperature is too high, and the controller can transmit a command to a valve field device commanding the valve to close, thereby lowering the temperature. In response to

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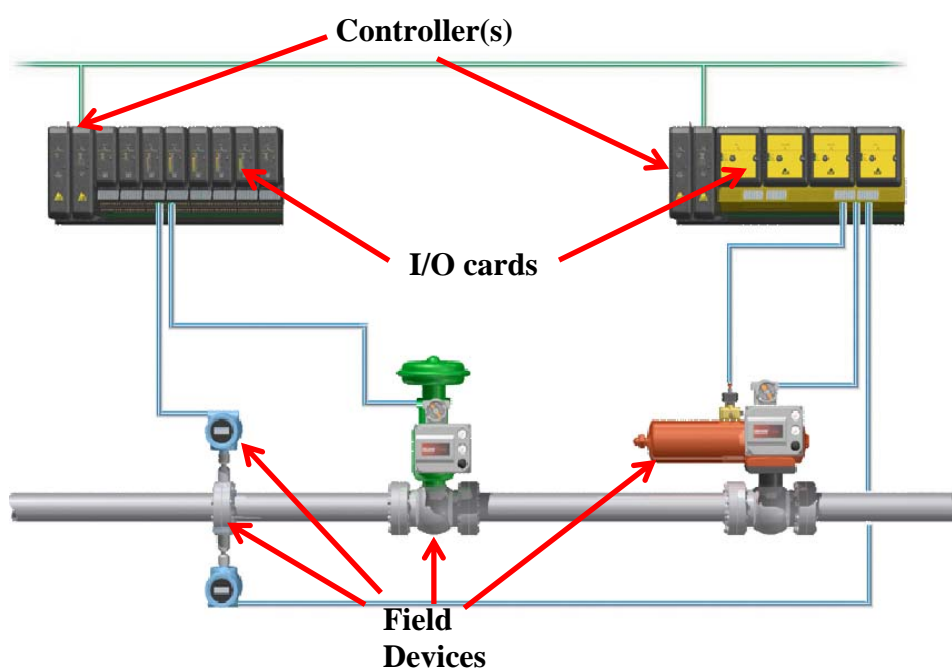
receiving the command from the controller, the valve can close as instructed and wait for another command from the controller. Subsequently, the valve may be commanded to open again once the controller determines that the temperature has lowered to an acceptable value.

This process seems simple on its face, but there are additional considerations that complicate the design of I/O. One of those complications stems from the fact that not all field devices communicate in the same manner. For example, some field devices communicate using *analog* signals, and some field devices communicate using *digital* signals. Furthermore, field devices generally communicate *unidirectionally*, meaning that field devices either send data to a controller (input device) or receive data or commands from the controller (output device). As such, the input/output cards of the I/O system must perfectly manage these one-directional signals and also manage signal types. As expected, miscommunication can occur easily due to improper connections. If an analog field device is connected to a digital I/O card, communication cannot occur, and the same is true for any digital-to-analog misconnection. Field devices are given a designation to reflect these differences, and the I/O cards reflect this designation: I/O cards receiving analog signals are called analog input (AI) cards, I/O cards receiving digital signals are called digital input (DI) cards, I/O cards sending analog signals are called analog output (AO) cards¸ and I/O cards sending digital signals are called digital output (DO) cards.

III.   THE PROBLEM:

Engineering a process control system generally requires two phases: an engineering, procurement, and construction (EPC) phase and an I/O design phase. The EPC phase defines the process, the number of field devices to accomplish the process, the types of field devices to accomplish the process, and the placement of the field devices. Below is a depiction of the initial design stage of a process control system by an EPC team.
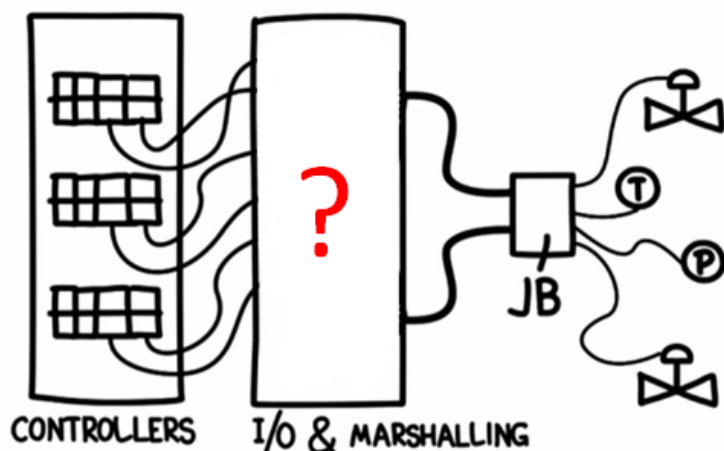
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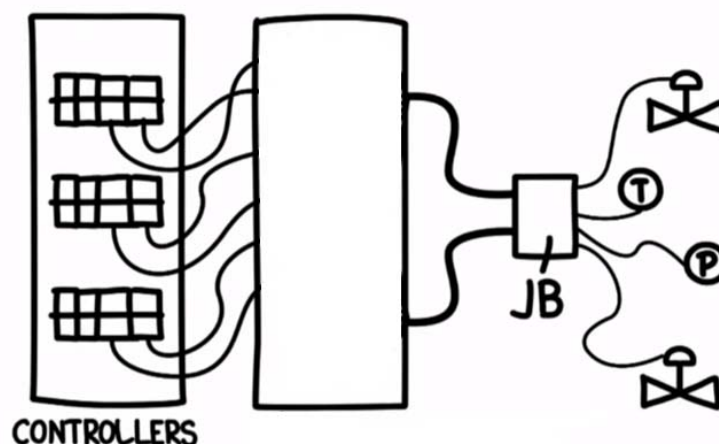
CONTROLLERS

Conversely, the I/O phase defines the *number and nature* of the connections necessary to interconnect the field devices and the controller(s) controlling the process. However, the I/O phase actually *depends* on the EPC phase because the EPC phase defines the number, placement, and types of field devices used in the process control system. In this sense the EPC phase is "coupled" to the I/O phase. The number of I/O devices critically impacts the scope of the

I/O phase engineering problems. Furthermore, the I/O phase is generally performed concurrently with the EPC phase to save time and costs. Adding to the *engineering problems*, the EPC phase *often changes* after creating initial specifications, which leaves the engineers in charge of the I/O phase chasing a moving target.

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Because I/O characteristics must reflect the field device to which it connects, the connections must be carefully designed and managed by engineering teams. The following example should illustrate how and why designing I/O for a process control system was *conventionally so difficult*. Let's say, for example, that the EPC team creates the simplified process control system shown here.


Notably, the EPC team has left the I/O system as a black box, allowing the I/O engineers to fill in the gaps. The I/O team needs to know at least the number of field devices because the number of field devices directly corresponds with the number of I/O connections necessary to interconnect the controller(s) and the field devices. As shown above at the initial EPC design phase, the EPC specification might specify the number of AI, AO, DI, and DO connections. These numbers drive everything including power, control, communication, wiring, and labor costs and considerations. And, the number of field devices could be in the thousands, meaning that the number of I/O connections is correspondingly in the thousands. Designing I/O is a difficult engineering problem regardless, but a high number of connections makes the I/O engineering problem even more difficult, especially when the EPC team changes the design late in the project lifecycle. The EPC team requires that the field devices be wired to an I/O connection landing and then the project shifts to the I/O team to make the proper connections.

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So, with hundreds or even thousands of field devices and I/O connections, the I/O team

has to manage as many electrical connections and ensure that the I/O connections bridge the
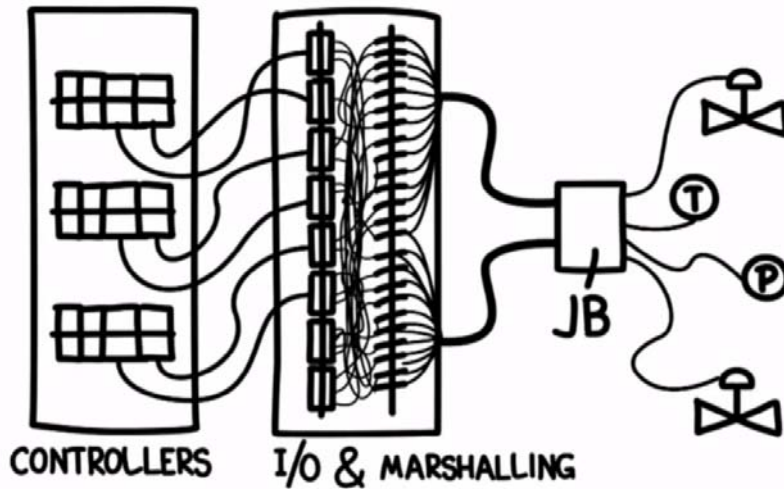
correct field devices to the correct controller. The resulting, conventional I/O project often ends up with a complex collection of wiring as shown below. As seen, the I/O black box gets filled in with hundreds or thousands of wires that

extend from the I/O connection landing to I/O cards that connect to the various controllers. The

wires often crisscross in a jumbled, messy web. The crisscrossing wires were often so complex

that I/O engineers frequently called it "spaghetti wiring". But, the process of getting a wire from

the connection landing to the correct I/O card was technically referred to "marshalling". An

example of a conventional marshalling cabinet having "spaghetti wiring" is illustrated below.
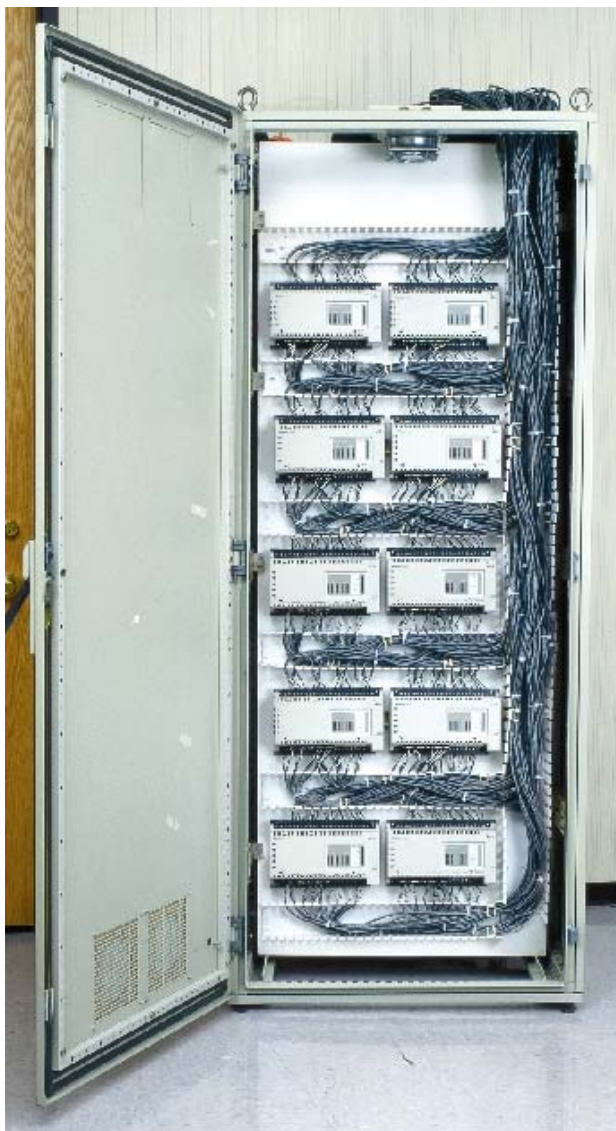
Beyond the obvious volume of wire and the number of connections that had to be made manually, the wiring process was actually quite complicated because field devices do not all speak the same "language" or "protocol". Field devices are considered AI, AO, DI, or DO, and I/O cards were labeled similarly. By way of example, assume that the topmost connection on the connection landing below corresponds to an analog field device transmitting data to a controller.
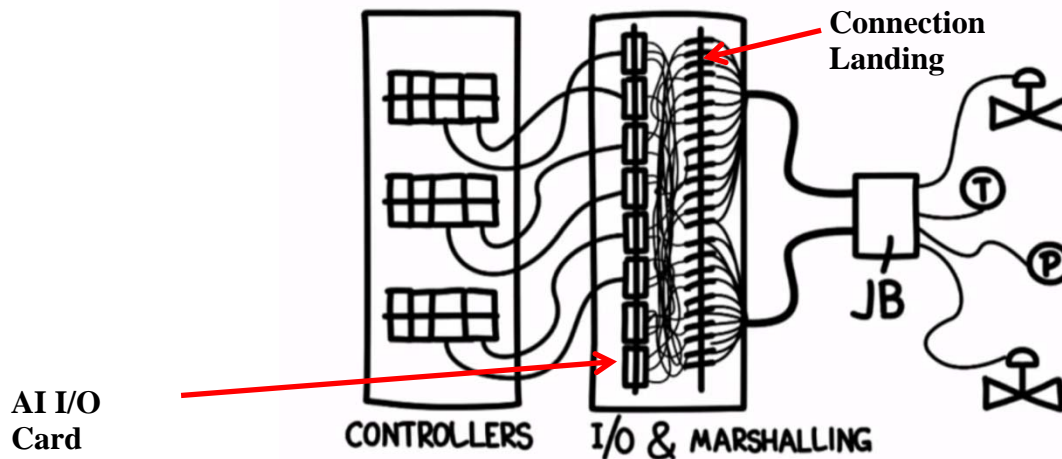
For the controller to actually *receive* the data from this analog field device, an I/O engineer must marshal the connection from the connection landing to an AI I/O card. But not just any AI I/O card: the marshalled connection must ensure that the field device communicates with the AI I/O card that ultimately communicates with the controller expecting to receive data from this analog field device. So, wiring between the connection landing and the I/O cards is not just time-consuming, it is also onerous. Worst of all, if any late changes happen during EPC, many, if not all, marshalled connections are now incorrectly wired/marshalled. Re-wiring under conventional marshalling systems was extremely costly, labor-intensive, but unfortunately very common.

IV.   THE SOLUTION

The apparatuses and systems claimed by the '567 and '769 Patents solved the spaghetti wiring and other problems
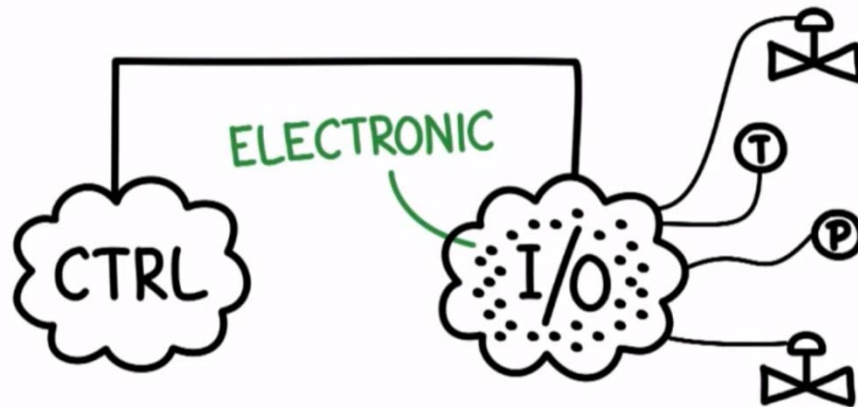
associated with conventional I/O. The inventions did so using a system represented by the simplified diagram shown above. Rather than *physically* and manually marshal connections using wires, the invention described by the '567 and the '769 Patents *electronically* marshals I/O connections using something akin to an I/O "cloud". Each connection is electronically marshalled rather than by physically moving a wire from one position to another.
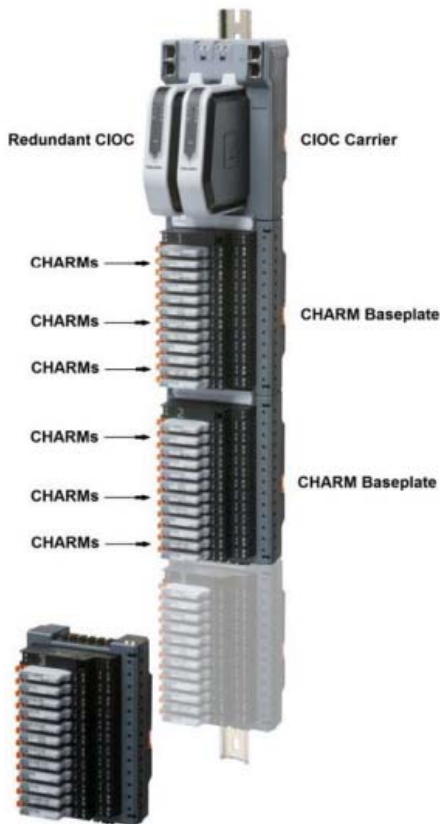
The '567 and '769 Patents accomplished electronic marshalling by using *single*-channel modules, which Emerson calls CHARMs (acronym for "characterization modules"). The modules replace the respective wires and marshal signals from the field electronically using data and signal management. As such, EPC engineers simply land wires anywhere on a first physical interface of a base (typically a screw terminal), and the

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location of that wire need not ever move. A typical CHARMs configuration looks something like

this:

To Controllers

CHARMS
modules
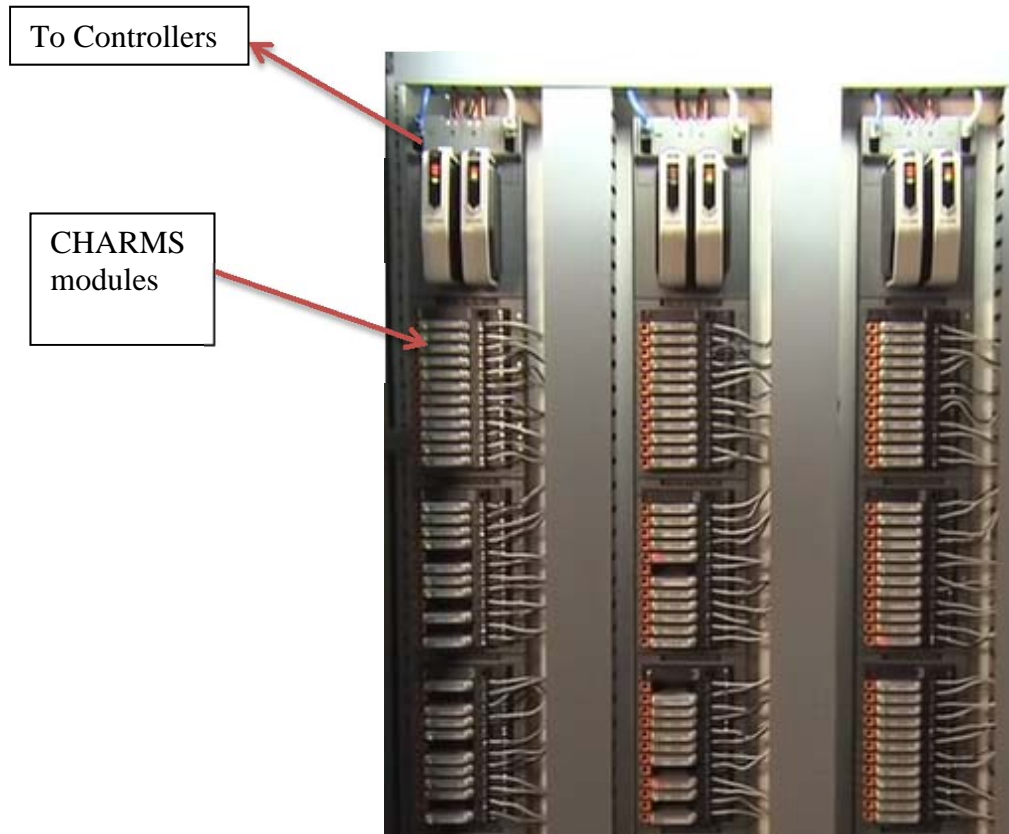
Wires from the field devices land on a first physical interface of a base located adjacent to the

modules (wiring shown in the photograph above right and below).

First physical interface
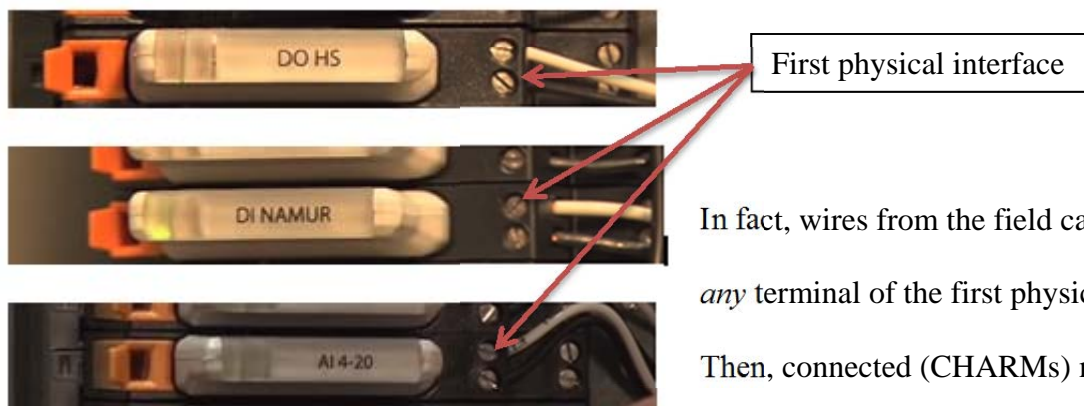
In fact, wires from the field can connect to

any terminal of the first physical interface.

Then, connected (CHARMs) modules

receive data from the field devices and

electronically marshal information to a controller through a network or a bus, which is not shown, but extends behind the modules. Generally, a bus is a communication medium that numerous devices (here, modules) can all use to transmit data in an ordered and organized fashion. Some modules receive a signal from a field device and marshal the signal to the appropriate controller by setting electronic values (e.g. network address values) and transmitting the signal plus the set electronic values via the bus. Generally, those electronic values include an address for the correct controller. Thus, the electronic data (an address) representing the controller replaces the physical wires. Other modules receive data from controllers via the bus and transmit the data to a field device

Each module communicates with a specific data type (AI, AO, DI, DO). The modules are removable and replaceable, so if any late changes occur, a module can simply be replaced with the appropriate module to prevent errors communication. For example, if a terminal originally receives an analog signal from the field, but later receives a digital signal from the field, an I/O engineer need only replace an AI module with a DI module. No rewiring required!
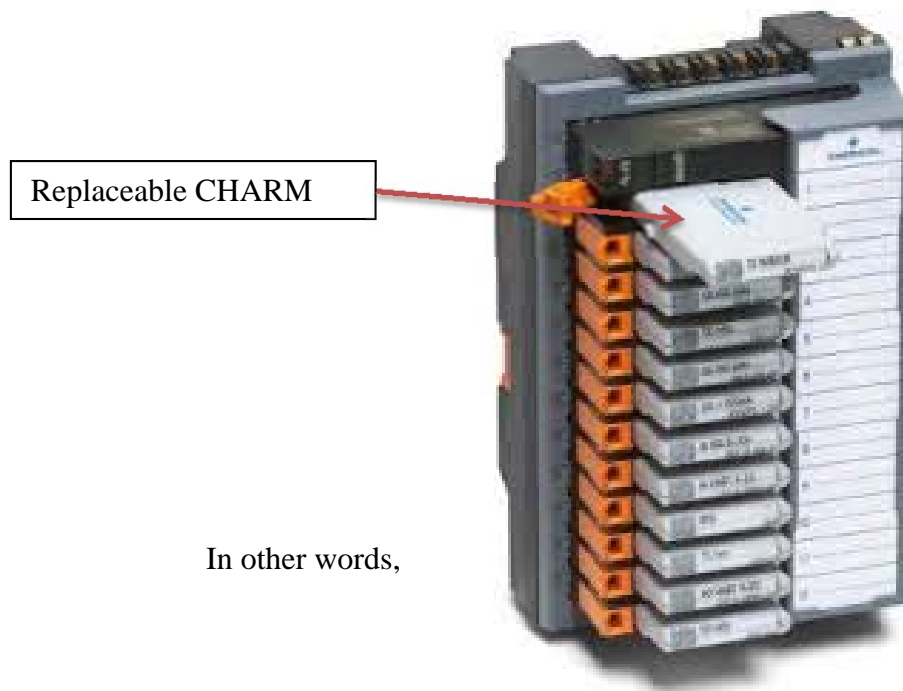
Replaceable CHARM

In other words,   the single-channel,

electronic marshalling module (CHARM) *completely replaces cross-wiring marshalling*. As shown below, in Figure 2 from the '567 Patent, each CHARM module communicates with only *one* field device.


FIG. 2
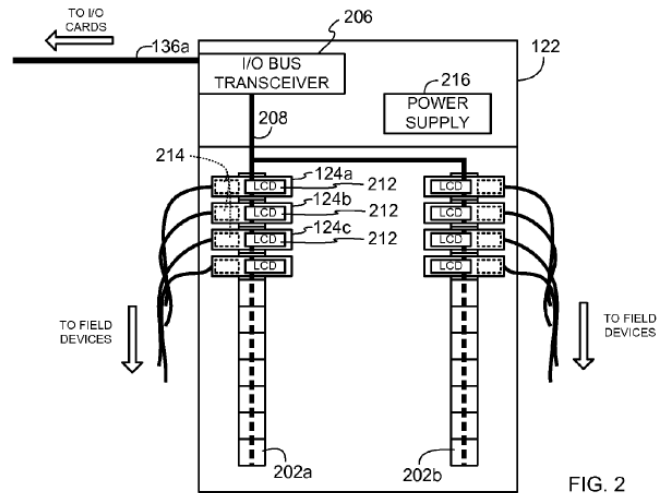
In summary, a module replaces difficult, messy cross-wiring because each module is single-channel and electronically marshals data from a field device to a specific controller via a bus.

Finally, regarding the '875 Patent, some field devices are "smart" devices, meaning they are more advanced and can communicate additional information to the I/O system and the controller, such as the smart device's name (also known as a device "*tag*"). Because smart devices (two examples are shown below) have advanced functionality, I/O engineers can configure the smart field devices and their corresponding I/O by simply clicking a few buttons on a computer screen.


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For example, as shown below, the I/O engineer can *auto-sense* CHARMs and field devices. The auto-sensing features of Emerson's patented electronic marshalling technology allow the I/O system and a connected personal computer to receive device tags from the smart field devices. After receiving the device tags, each tag can be compared to values in a database to identify matches, mismatches, and connection errors. The auto-sensing feature can also identify additional data about the smart field device, such as device type, power requirements, or data about the CHARM itself.
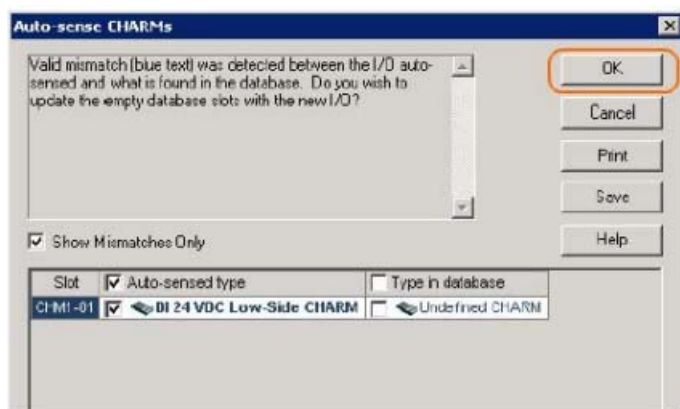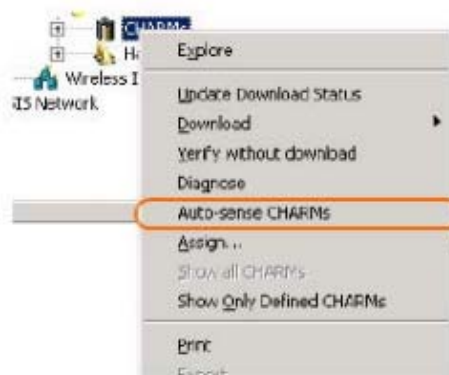
Once properly commissioned, the field device can be associated with a process control routine executed by a controller. In other words, the controller knows where to look for data or where to send commands for decisions made by a process control routine executed by the controller. The I/O engineer can enter data into the database to allow a computer to automatically configure the I/O without individually configuring each CHARM.

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FIG. 2
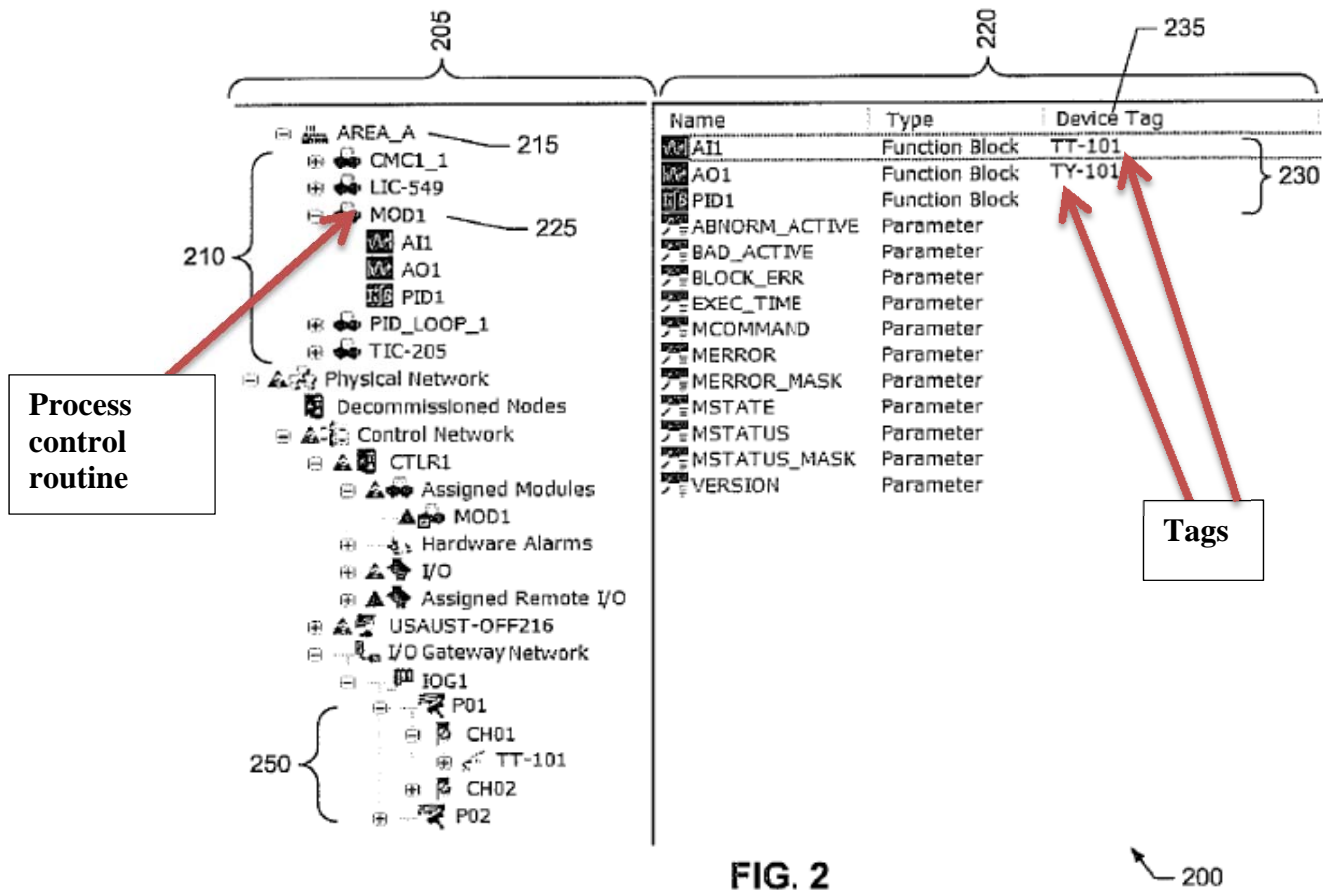
In the example shown above, the process control routine MOD1 receives data from field device "TT-101" and sends data to field device "TY-101". Each of "TT-101" and "TY-101 is a device tag, and the process control routine MOD1 has been electronically configured with these device tags.

In summary, the inventions described by the '567, '769, and '875 Patents solved the major and costly wiring issues related to process control I/O, including arduous configuration and time-consuming physical wiring from a connection landing to an I/O card. The single-channel CHARMs I/O modules perform electronic marshalling to replace physical wiring marshalling and thereby simplify I/O configuration and drastically reduce the cost to customers. In effect, EPC tasks are "decoupled" from I/O tasks. In addition, electronic marshalling made

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automatic electronic configuration possible by using device tags to further simplify process

control I/O, especially late term changes in I/O design.

Dated: September 25, 2019

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that on this 25th day of September 2019, I caused the foregoing to be

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